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(54) Title of the Invention: SEMICONDUCTOR DEVICE AND MANUFACTURING  
METHOD THEREOF

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SPECIFICATION

1. Title of the Invention  
SEMICONDUCTOR DEVICE AND MANUFACTURING METHOD THEREOF

## 2. Scope of Claims

(1) A manufacturing method of a semiconductor device, is characterized by comprising the steps of:

forming a semiconductor thin film on a heat resistant substrate having a mechanical strength necessary for supporting the semiconductor thin film, in a temperature necessary for forming the semiconductor thin film;

joining a base body on the semiconductor thin film; and  
peeling off the heat resistant substrate from the semiconductor thin film.

(2) The manufacturing method of a semiconductor device according to claim 1, the manufacturing method being characterized in that the heat resistant substrate and the semiconductor thin film are separated from each other by previously covering at least a part of a surface of the heat resistant substrate with a release layer before forming the semiconductor thin film on the heat resistant substrate, and by dissolving the semiconductor thin film in the step of peeling off the heat resistant substrate from the semiconductor thin film.

(3) The manufacturing method of a semiconductor device according to claim 1 or claim 2, the manufacturing method being characterized in that the step of forming the semiconductor thin film includes:

a step of performing zone melting recrystallization on the provided semiconductor thin film.

(4) A semiconductor device is characterized by being constituted of a semiconductor thin film and a base body as a result of joining the semiconductor thin film to the base body to in a temperature necessary to form the semiconductor thin film, the semiconductor thin film being formed on a heat resistant substrate having a mechanical strength necessary to hold the semiconductor thin film and the base body having a mechanical strength necessary to hold the semiconductor thin film; and peeling off the heat resistant substrate from the semiconductor thin film.

(5) A semiconductor device is characterized in that with a semiconductor device having a semiconductor thin film on the base body according to claim 4 as a second base body, a second semiconductor thin film is formed on the second base body with an insulating material interposed therebetween.

## 3. Detailed Description of the Invention

[Field of the Industrial Application]

The present invention relates to a functional device in which a semiconductor thin film is used and to a manufacturing method thereof.

[Prior Art]

Hereinbelow, conventional technologies relating to a functional device in which a semiconductor thin film is used will be explained below with examples.

For example, Fig. 13 is a cross-sectional schematic view showing a structure of an example of a conventional semiconductor device, in which a semiconductor thin film is used, step by step in accordance with manufacturing steps thereof. In this drawing, reference numeral 1 denotes a heat resistant substrate; 108, a diffusion prevention layer; 2, a semiconductor thin film; 5, a cap layer; 11, a p-n junction layer provided on the surface of the semiconductor thin film 2; and 12, grid electrodes.

For the heat resistant substrate 1, for example, silicone,

a refractory metal, graphite, conductive ceramics or the like is used (Fig. 13(a)). On the surface thereof, the diffusion prevention layer 108 formed of a silicon oxide film is formed (Fig. 13(b)). Next, openings 109 are provided by removing a part of the diffusion prevention layer 108 by use of a method such as a photo-engraving method (Fig. 13(c)). The semiconductor thin film 2 is formed thereon by use of a method of, for example, decomposing semiconductor material gas such as silane, dichlorosilane and trichlorosilane (Fig. 13(d)). The cap layer 5 formed of a silicon oxide film covers the semiconductor thin film 2 (Fig. 13(e)). After heat is applied from above the cap layer 5 to the semiconductor thin film 2 to melt and recrystallize the semiconductor thin film 2 (Fig. 13(f)), the cap layer is etched and removed (Fig. 13(g)). Thereafter, the junction layer 11 is formed by causing a microcrystalline film to grow on the surface of the semiconductor film or by impurity diffusion. A transparent conductive film (not shown) is provided, if necessary. Further, the grid electrodes 12 are provided, and then the semiconductor device is completed (Fig. 13(h)).

When a semiconductor device thus obtained is irradiated with a light in the arrow direction shown in Fig. 13(h), the light is absorbed inside the semiconductor device. By the p-n junction provided in the semiconductor device, an electromotive force is generated in a thickness direction of the semiconductor thin film 2, whereby an electric current can be extracted. A part of the electric current is extracted from the grid electrodes 12, and the other part thereof is extracted from the heat resistant substrate 1 through openings 109 provided to the diffusion prevention layer 108. Fig. 14 is a configuration of a semiconductor device announced in 20th IEEE Photovoltaic Specialists Conference. In this case, polycrystalline silicon is used as the heat resistant substrate 1, and silicon is used as a material of the semiconductor thin film 2. However, in a manufacturing method of the semiconductor device as described above, when a the semiconductor thin film 2 is formed on the diffusion prevention layer 18, or when the semiconductor thin film 2 is melted and recrystallized, a process in a state of high temperature is performed. For this reason, there has been a problem that if damaging impurities such as Fe, Ni, or Cr, which deteriorates characteristics of a semiconductor device, is contained in the heat resistant substrate 1, these impurities are diffused into the semiconductor thin film 2 through the openings 109 provided to the diffusion prevention layer 108, whereby a performance of the semiconductor device is deteriorated. Furthermore, in a semiconductor device having a configuration as described above, an electric contact between the semiconductor thin film 2 and the heat resistant substrate 1 is achieved with the openings 109 provided to the diffusion prevention layer 108. Since a material having conductivity is used as the heat resistant substrate 1 and the whole thereof is used as electrodes, it has been difficult to realize a configuration in which the semiconductor thin film 2 provided on the heat resistant substrate 1 is formed into a plurality of separated regions and the regions are electrically connected, that is, an integrated configuration.

Further, Fig. 15 is a cross-sectional view showing a concept of a configuration according to another example of semiconductor devices, which has been conventionally proposed.

In the drawing, reference numeral 101 denotes a silicon substrate; 118, an integrated circuit region formed on the silicon substrate 101; 2, semiconductor thin films; 119, an integrated circuit region formed on the semiconductor thin film 2; 120, an interlayer insulating film; and 121, interconnection.

On the surface of the silicon substrate 101, the integrated circuit region 118 is formed, and two layers of semiconductor thin films 2 are provided thereon with the interlayer insulating film 120 interposed therebetween. The integrated circuit region 119 is formed on the respective semiconductor thin films 2. The integrated circuit 118 on the silicon substrate 101 and the integrated circuit 119 on the semiconductor thin film 2 are electrically connected to each other by the interconnection 121, whereby the semiconductor device is obtained in which respective integrated circuits exercise a collected function. In order to constitute the above configuration, taken is a manufacturing method in which, the integrated circuit region 118 is first formed on the silicon substrate 101, the interlayer insulating layer 120 and the semiconductor thin film 2 are sequentially provided thereon, and the integrated circuit is connected to the integrated circuit regions 118 and 119, which are lower layers, by the mutual interconnection 121. For the semiconductor thin film 2 used for the semiconductor device having such a configuration, polycrystalline silicon or one obtained by melting and recrystallizing polycrystalline silicon is generally used. In consideration of electric characteristics as a semiconductor thin film, rather than using polycrystalline silicon as it is, it is preferable to use one obtained by melting and recrystallizing polycrystalline silicon once, whereby a polycrystalline region is enlarged. However, in a semiconductor device having the configuration as above, as described above, in a case where the manufacturing method in which a configuration is made by sequentially superposing the semiconductor thin film 2 on the silicon substrate on which the integrated circuit region 118 is formed, it should be avoided that, in order to protect functions of the formed integrated circuit, the integrated circuit region once formed in the manufacturing process are exposed to a temperature of not lower than 800. to 900.. On the other hand, for the purpose of melting and recrystallizing the semiconductor thin film 2, in a case of silicone, it melts at 1414.. Accordingly, it is necessary to expose the semiconductor thin film 2 to a temperature not lower than 1414.. Since this contradicts the above-described requirement, it has been difficult to realize such a semiconductor device.

To solve this, there has been an attempt to realize the semiconductor device as described above by irradiating the semiconductor thin film 2 with a laser beam or an electron beam and locally heating the semiconductor thin film 2 to minimize effects to be given to the integrated circuit region which has already been formed. For example, Fig. 16 is an example of the semiconductor device announced in IEDM Technical Digest (1981). In the drawing, reference numeral 101 denotes a p-type silicon substrate; 130, n-type diffusion regions formed on the silicon substrate 101; 131, a silicon oxide film; 132, a first polycrystalline silicon layer; and 133, a second polycrystalline silicon layer. The second

polycrystalline silicon layer 133 corresponds to the semiconductor thin film 2 in Fig. 15. The silicon oxide film 131 corresponds to the interlayer insulating layer 120 in Fig. 15, the silicon oxide film 131 being between the silicon substrate 101, and the second polycrystalline silicon layer 133 and the first polycrystalline silicon layer 132. Additionally, a contact portion of the second polycrystalline silicon layer 133 and the n-type diffusion regions 130 correspond to the interconnection 121 in Fig. 15. In this example, the first polycrystalline silicon layer 132, two n-type diffusion regions 130 and the p-type silicon substrate 101 constitute a circuit device which is a component of an integrated circuit. The first polycrystalline silicon layer 132, and the second polycrystalline silicon layer 133 placed directly thereabove constitute another circuit device. These circuit devices are electrically connected and form an integrated circuit. Laser beam irradiation is used for melting and recrystallizing the semiconductor thin film, that is, the second polycrystalline silicon layer 133. As described, for example, by adopting laser beam irradiation, although a semiconductor device having such a complex configuration as shown in Fig. 15, has not been realized, a similar semiconductor device having a more simple structure, which can be said as a prototype thereof, has been gradually realized. However, in such a manufacturing method, it is difficult to obtain a monocrystalline region across a large area in the semiconductor thin film 2 obtained by recrystallization using laser beam irradiation. Therefore, it is not possible to form a large-scaled complicated integrated circuit on the semiconductor thin film 2. Additionally, there has been a problem that it requires a long time to apply laser beam irradiation to the large area and productivity is deteriorated. [Problems to be Solved by the Invention]

Since the conventional semiconductor device and the manufacturing method thereof are constituted as described, there have been problems such as difficulties in inhibiting intrusion of impurities, realizing an integrated structure, and making the area larger, as well as a poor productivity.

The present invention is made to solve the problems above, and an object is to provide a semiconductor device and a manufacturing method thereof which can solve all of the above-described problems.

[Means for solving the Problems]

In the manufacturing method according to the present invention, after a semiconductor thin film is formed on a heat resistant substrate and a base body is formed on the semiconductor thin film, the semiconductor thin film is peeled off from the heat resistant substrate.

Further, in the semiconductor device according to the present invention, after the semiconductor thin film is formed on the base body by use of the manufacturing method of the semiconductor device according to the present invention.

[Operations]

In the method of manufacturing a semiconductor device according to the present invention, after a semiconductor thin film is formed on a heat resistant substrate once, the semiconductor thin film is transferred to a base body.

In addition, the semiconductor device according to the present invention is constituted in a manner that a semiconductor thin film once formed on a heat resistant substrate is transferred

to a base body of the semiconductor device.

[Example]

Hereinbelow, an example of the present invention is explained with reference to drawings. Fig. 1 is a schematic cross-sectional view for explaining manufacturing method of a semiconductor device according to a first example of the invention step by step in accordance with manufacturing steps thereof. In the drawings, reference numerals 1, 2, and 3 denote a heat resistant substrate, a semiconductor thin film, and a base body of the semiconductor device, respectively.

In the drawing, a heat resistant substrate 1 (Fig. 1(a)) must be one the shape and composition of which do not change in a temperature necessary for forming a semiconductor thin film. For example, in a case where the semiconductor thin film 2 is polycrystalline silicon, in order to form the semiconductor thin film by use of decomposition of a semiconductor material gas, the heat resistant substrate 1 has to have heat resistance to a temperature between at least 600° and about 1200°. Additionally, in a case where the semiconductor thin film 2 is amorphous silicon, a material resistant to a temperature of about 300 may be used. As a material for the heat resistant substrate 1 satisfying this requirement, in the former case, for example, quartz, carbon, silicon, ceramics, a high-melting-point metal, or the like, in the latter case, glass, a metal such as a stainless metal, heat resistant resin, or the like, can be used.

The semiconductor thin film 2 is formed on the surface of the heat resistant substrate 1 by use of means such as decomposition of a semiconductor material gas (Fig. 1(b)). If necessary, this semiconductor thin film 2 undergoes necessary processing for application to the semiconductor device to be configured with this semiconductor device 2, the processing being, for example, patterning, oxidation, impurity diffusion, annealing, recrystallization, epitaxial growth, and forming a lamination layer of another thin film and patterning thereof, and the like. On the semiconductor thin film 2A, a base body 3 of the semiconductor device to be formed with the semiconductor thin film 2 is joined (Fig. 1(c)). For the joining, the base body 3 may be directly joined to the semiconductor thin film 2, or a bonding agent may be used. In addition, a bonding agent itself may be used as the base body 3. Direct joining is possible in a case where the contact portion between the base body and the semiconductor thin film 2 has sufficient adhesiveness with the semiconductor thin film 2. The cases are, for example, where the bonding agent is used as the base body 3, and where, by the processing for the semiconductor thin film 2 in the step of forming the semiconductor thin film 2, a material having high adhesion to the base body is placed on the surface thereof or the surface of the semiconductor thin film 2 becomes to have a surface shape highly adherent to the base body, that is, for example, a case where integrated circuits are formed and irregularities are formed thereon. It is also possible to intentionally perform processing on the surface of the semiconductor thin film 2 for the purpose of improving the adherence to the base body 3. As the bonding agent, it is possible to use, for example, an organic matter film such as a polyimide-based resin, low-melting point glass, silicon oxide film to which phosphorus or boron is added.

Hereinafter, the heat resistant substrate 1 is peeled off from the semiconductor thin film 2 (Fig. 1(d)). In a case where the heat resistant substrate 1 is formed of a porous material such as porous ceramics, for example, a material for dissolving the semiconductor thin film 2 in the heat resistant substrate 1, that is, an etchant or an etching gas, is caused to permeate the heat resistant substrate 1 for partly dissolving a part of the semiconductor thin film contacting the heat resistant substrate 1, whereby the join between the heat resistant substrate 1 and the semiconductor thin film 2 is removed. Accordingly, it is made possible to peel off the heat resistant substrate 1 from the semiconductor thin film 2. In a case where the semiconductor thin film 2 is formed of polycrystalline silicon, for example, it is possible to use, as the etchant, a mixture of HF, HNO<sub>3</sub> and CH<sub>3</sub>COOH, or the like, and as the etching gas, ClF<sub>3</sub> or the like. Because of this, the semiconductor device having a structure, in which the semiconductor thin film 2 is placed on the base body 3, is formed.

Fig. 2 and Fig. 3 show second and third examples of the present invention in a case of previously providing a release layer 4 before forming a semiconductor thin film 2 on a surface of a heat resistant substrate 1. The release layer 4 is provided to at least a part of the surface of the heat resistant substrate 1 (Fig. 2(a), and Fig. 3(b)). The semiconductor thin film 2 is formed on the release layer 4, and a base body 3 is joined thereto (Fig. 2(c), and Fig. 3(c)), as in the case shown in Fig. 1.

The second example in Fig. 2 shows a case where, in the step of peeling off the heat resistant substrate 1 from the semiconductor thin film 2, the heat-resistant substrate 1 is peeled from the semiconductor thin film 2 by chemically dissolving with a solvent the release layer 4 which is provided between the heat resistant layer 1 and the semiconductor thin film 2. In a case where the solvent infiltrates into the space between the semiconductor thin film 2 and the heat resistant substrate 1, that is, a portion where the release layer 4 occupies, the heat resistant substrate 1 may be airtight one. However, in a case where the semiconductor thin film 2 has a large surface area, porous one is used. For example, in the case where the semiconductor thin film 2 is formed of polycrystalline silicon, a silicon oxide film, and porous ceramics or the like, are used respectively as the release layer 4 and the heat resistant substrate 1. For example, porous alumina or the like is used as the porous ceramics. In this case, it is possible to use HF as a solvent for the release layer 4. In the case of using a porous material for the heat resistant substrate 1, it is not possible to obtain a surface having enough flatness depending on quality of material in some cases. However, it is possible to obtain a flat surface by providing the release layer 4 to flatten the surface of the release layer 4. For example, in a case of using a silicon oxide film as the release layer 4, it is possible to obtain a flat surface by using an oxide film to which phosphorus or boron is added to perform a reflow.

The third example in Fig. 3 shows a case where, in the step of peeling off the heat resistant substrate 1 from the semiconductor thin film 2, by physically dissolving the release layer 4 provided between the heat resistant substrate 1 and the semiconductor thin film 2, the heat resistant

substrate 1 is peeled off from the semiconductor film 2. As the release layer 4, for example, silicon, silicon nitride, a silicon oxide film, silicon carbide, or a layer formed by applying boron nitride thereto, the cohesion between the semiconductor thin film 2 and the heat resistant substrate 1 depends on a weak cohesion between molecules of these powders. Accordingly, in this case, it is possible to separate the heat resistant substrate 1 and the semiconductor thin film 2 by applying a mechanical stress to peel off the heat resistant substrate 1 from the semiconductor thin film 2, thereby dissolving the release layer 4 (Fig. 3(d)). Additionally, a layer obtained by, for example, covering it with a silicon oxide film may be the release layer 4.

Further, Fig. 4 shows a forth example of the present invention in a case of melting and recrystallizing the semiconductor thin film 2 once formed in the step of forming the semiconductor thin film on the heat resistant substrate 1. For example, the release layer 4 formed of a silicon oxide film is provided on the surface of the heat resistant substrate 1 formed of porous alumina or the like by using a vapor phase method (Fig. 4(a)). A polycrystalline silicon film is formed thereon as the semiconductor thin film 2 by use of the vapor phase method, and again, it is covered with a cap layer 5 formed of silicon oxide film by using a vapor phase method (Fig. 4(b)). A silicon nitride film may be further provided thereon. Next, after being heated and melted, the semiconductor thin film 2 is fixed and recrystallized (Fig. 4(c)), the cap layer 5 is removed. Subsequently, a base body 3 is joined on the semiconductor film 2 (Fig. 4(d)), HF is caused to infiltrate into the heat resistant substrate 1, the silicon oxide film of the release layer 4 is dissolved, and the heat resistant substrate 1 is peeled off (Fig. 4(e)). For heating and melting the semiconductor thin film 2, an energy beam such as a laser or an electron beam maybe used, or heating by infrared radiation and a carbon heater or the like may be used. It is also possible to perform zone melting recrystallization in which a band-shaped melting part is formed in the semiconductor film 2 by irradiating an infrared light linearly onto the semiconductor film 2, or by a linear carbon heater or the like, and the band-shaped melting part is moved. Additionally, in the above-describe example, a case where both of the release layer 4 and the cap layer 5 are formed of silicon oxide film 5 was shown. However in the case of using HE for removing the cap layer 5, the surface thereof is covered with a protective material in order not that the release layer 4 is removed at the same time at this time.

Fig. 5 shows a fifth example of the present invention and is one showing a similar example as the forth example in Fig. 4. In the step of forming a semiconductor thin film 2, a semiconductor crystal 6 is placed to be adjacent to the heat resistant substrate 1 so as to have the same surface as that of the heat resistant substrate 1 (Fig. 5(a)), and the semiconductor thin film 2 is formed on both of the heat resistant substrate 1 and the semiconductor crystal 6 (Fig. 5(b)). The same material of the semiconductor thin film 2 is used for the semiconductor crystal 6. For example, in a case where the semiconductor thin film 2 is polycrystalline silicon, a silicon monocrystal is used for the semiconductor crystal 6. Next, when performing the zone melting recrystallization on the semiconductor thin film 2, the semiconductor thin film 2

on the semiconductor crystal 6 is firstly heated and melted, the heated portion is caused to move. Then, the semiconductor thin film 2 on the heat resistant substrate 1 is sequentially caused to melt from the edge thereof and is caused to sequentially coagulate from the portion above the semiconductor crystal 6 to the portion above the heat resistant substrate 1. By this operation, the semiconductor thin film 2 on the semiconductor crystal 6 is drawn into a crystal orientation of the semiconductor crystal 6, and tends to coagulate with the same crystal orientation. The semiconductor thin film 2 on the heat resistant substrate 1 is also drawn into the portion of the semiconductor thin film 2 and tends to coagulate with the same crystal orientation, the portion having coagulated with the same crystal orientation as the semiconductor crystal 6. For this reason, a large portion of the semiconductor thin film 2 after the recrystallization thereof coagulates with the same crystal orientation as the semiconductor crystal 6, whereby it is possible to obtain the semiconductor thin film 2 having a monocrystal region in a large surface area. Further, an advantage when performing the zone melting recrystallization is that in a case where impurities are included in the semiconductor thin film 2, impurities with a small segregation coefficient are pulled to get together, whereby purification is performed along with the recrystallization. As similar to ones shown according to Fig. 4, in the following steps, a base body 3 is joined to the semiconductor thin film 2 (Fig. 5(d)), the heat resistant substrate 1 is separated by dissolving the release layer 4 (Fig. 5(e)), and further, the semiconductor crystal 6 is separated (Fig. 5(e)).

Fig. 6 is a schematic cross-sectional view for explaining a sixth example of the present invention step by step in the accordance with steps of the manufacturing method, the example being in a case where the manufacturing method of a semiconductor device according to the present invention shown above is applied to a real semiconductor device. A release layer 4 (Fig. 6(a)) is provided on a heat resistant substrate 1 (Fig. 6(b)). As a semiconductor thin film 2, for example, a p-type polycrystalline silicon thin film is formed thereon (Fig. 6(c)) and is covered with a cap layer 5 (Fig. 6(d)). After zone melting recrystallization is performed on the semiconductor thin film 2 (Fig. 6(e)), the cap layer 5 is removed (Fig. 6(f)), and a p<sup>+</sup> diffusion layer 7 and an oxide film 8 are formed on the surface of the semiconductor thin film 2 (Fig. 6(g)). Next, the oxide film 8 is patterned to provide openings 9 in some portions thereof (Fig. 6(h)), a metal layer 10 is formed thereon by use of sputtering, vacuum vapor deposition or the like for aluminum, silver or the like (Fig. 6(i)), and a base body 3 is joined (Fig. 6(j)). Subsequently, the release layer 4 is dissolved to separate the heat resistant substrate 1 (Fig. 6(k)), a junction layer 11 is provided on the surface of the semiconductor thin film 2 to form a p-n junction by use of n<sup>+</sup> diffusion, or an n-type microcrystal film or the like, and further, grid electrodes 12 are provided on the surface thereof (Fig. 6(l)). When the semiconductor device thus obtained is irradiated with a light in a direction shown by arrows 13 in Fig. 6(l), the light is absorbed inside the semiconductor device, and an electromotive force is generated in a film thickness direction of the semiconductor thin film 2 because of the p-n junction provided

in the semiconductor device, whereby it is possible to extract an electric current. A part of the electric current is extracted from the grid electrodes 12, and the other part thereof is extracted from the metal layer 10 through openings 9 provided to the oxide film 8. In addition, the metal layer 10 has a function of reflecting a light to be made incident again on the semiconductor thin film 2, in a case where the light made incident is not absorbed enough by passing through the semiconductor thin film 2 once. According to this method, since melting and recrystallizing of the semiconductor thin film 2 is performed in a state where the all surface thereof is covered with the release layer 4 and the cap layer 5, it is possible to prevent contamination because of impurities upon the heating and melting thereof.

Further, Fig. 7 shows a semiconductor device according to a seventh example of the present invention step sequentially in accordance with manufacturing steps thereof, the semiconductor device being similar to that shown in Fig. 6. The steps in Figs. 7(a) to 7(f) are similar to those in Figs. 6(a) to 6(f). In Fig. 7, a junction layer 11 is formed on the surface of the semiconductor thin film 2 to provide grid electrodes 12 (Fig. 7(g)) and a translucent base body 3 is joined thereon (Fig. 7(h)). Thereafter, the release layer 4 is dissolved to separate the heat resistant substrate 1 (Fig. 7(i)) and a metal layer 10 is provided to be a back-surface electrode (Fig. 7(j)). In this case, a light is irradiated from the translucent base body 3 side as shown by arrows 13.

In the example shown above, the semiconductor device in which the semiconductor thin film 2 is used without patterning. However, the semiconductor thin film 2 may be separated into regions each having an appropriate size, and used. Fig. 8 shows an eighth example of the present invention in this manner. Steps in Figs. 8(a) to 8(f) are similar to those in Figs. 6(a) to 6(f). In Fig. 8(g), a p<sup>+</sup> diffusion layer 7 is formed on the semiconductor thin film 2. An oxide film 8 may be provided as in Fig. 6. However, a case where no oxide film 8 is provided is shown in the drawing for the purpose of simplifying the drawing. After a metal layer 10 is provided thereon (Fig. 8(h)) and is then patterned (Fig. 8(i)), a base body 3 is joined thereon (Fig. 8(j)). The release film 4 is dissolved to separate the heat resistant substrate 1 (Fig. 8(k)). Further, the semiconductor thin film 2 is divided in conformity with the pattern of the metal layer 10 to perform patterning (Fig. 8(l)). At this time, as shown in the figure, for example, a part of the metal layer 10 is caused to be exposed to a space formed by the division of the semiconductor thin film 2. Thereafter, a p-n junction layer (not shown) is formed on the semiconductor thin film 2. Grid electrodes 12 are formed so as to contact the metal layer 10 whose one part is exposed to the space of the semiconductor thin film 2 (Fig. 8(m)). Accordingly, in a case where a semiconductor device is, for example, a semiconductor element for generating an electric power by use of the light irradiation as shown in Figs. 6 and 7, it is possible to obtain the semiconductor device having a configuration in which a plurality of power generation regions depending on the semiconductor thin film 2 are provided on the base body 3 and are connected in series to each other.

In the above-described example, the case where the grid electrodes 12 are used to electrically connect the divided

semiconductor thin film 2. However, for example, a transparent conductive film or the like may be used. Further, a power generation element of a second semiconductor thin film may be superposed on the power generation region of the semiconductor thin film 2. For example, in a ninth example shown in Fig. 9, a state of processing of the space of the semiconductor thin film 2 in this case is shown step by step. A semiconductor thin film 2 which is divided, and on which a p-n junction layer (not shown) is formed, is covered with a power generation element of the second semiconductor thin film 14, the semiconductor thin film 2 being, for example, amorphous silicon or the like and the second semiconductor thin film 14 being of, for example, polycrystalline silicon or the like (Fig. 9(a)). After a portion of this second semiconductor thin film 14 is melted by use of, for example, a laser beam or the like to be removed (Fig. 9(b)), the portion is covered with a transparent conductive film 15 (Fig. 9(c)). Furthermore, parts of the second semiconductor thin film 14 and the transparent conductive film 15 are cut and removed at the same time (Fig. 9 (d)).

In addition, as shown in a tenth example of Fig. 10, after a second semiconductor thin film 14 and a transparent conductive film 15 are formed on an entire surface area (Fig. 10 (a)), two portions are cut and removed by use of, for example, a laser beam or the like (Fig. 10 (b)). Thereafter, one of the cut portions is filled with, for example, a conductive paste or the like, whereby electrical connection is made between the transparent conductive film 15 and a metal film 10 (Fig. 10 (c)). Accordingly, it is possible to obtain a semiconductor device having a configuration in which power generation elements having a laminated structure of the semiconductor thin film 2 and the second semiconductor thin film 14 are provided on the same base body 3 in a plurality of regions and are connected in series.

Figs. 11 and 12 are schematic cross-sectional views for explaining eleventh and twelfth examples of the present invention step by step in accordance with manufacturing steps thereof, the examples being in a case where the manufacturing method of a semiconductor device according to the present invention shown above is applied to still another semiconductor device. The examples shown herein relate to a semiconductor integrated circuit using a semiconductor thin film, and particularly relate to a semiconductor device having a structure in which an integrated circuit is formed and multiple semiconductor thin films are superposed. Steps in Figs. 11(a) to 11(f) and Figs. 12(a) to 12(f) are similar to those in Figs. 6(a) to 6(f). As shown in Fig. 11, on a semiconductor thin film 2 formed on a heat resistant substrate 1 with a release layer 4 interposed therebetween, for example, a base body 3 is joined by using an electrical insulating bonding agent 17 such as a polyimide based resin or low-melting point glass (Fig. 11(g)). After the release layer 4 is dissolved to separate the heat resistant substrate 1 (Fig. 11(h)), an integrated circuit region 18 is formed by performing processing on the semiconductor thin film 2 (Fig. 11(i)). The base body 3 and the bonding agent 17 may be any ones as long as they are resistant to the processing for forming the integrate circuit region 18. For example, if a semiconductor substrate, on which integrated circuits have been originally formed, is used, it is possible to obtain a

semiconductor device having a structure, in which integrated circuits are provided and superposed with an insulating material therebetween. Furthermore, if the semiconductor thin films 2 are repeatedly superposed with the semiconductor device of this example as the base body 3, it is possible to obtain a semiconductor device having a structure in which an integrated circuit is provided and multiple semiconductor thin films are superposed.

Further, as shown in Fig. 12, it is possible that on a heat resistant substrate 1, an integrated circuit region 18 is formed on the surface thereof (Fig. 12(g)) before separating a semiconductor thin film 2, thereafter a base body 3 is joined thereto (Fig. 12(h)), and the heat resistant substrate 1 is separated (Fig. 12(i)). In this case, because it is not necessary that the base body 3 and a bonding agent 17 are resistant to the processing for forming an integrated circuit, the base body 3 may be any one as long as it is capable of mechanically supporting the semiconductor thin film 2, and a degree of freedom in selecting a material thereof is large.

As above, according to the manufacturing method of a semiconductor device of the present invention, since melting and recrystallizing of the semiconductor thin film 2 are performed on the heat resistant substrate 1, it is possible to configure a semiconductor integrated circuit having a multilayered structure, without an influence on operations of the integrated circuit previously formed because of an increase in a temperature during recrystallization. Further, because of this, since it is possible to use heating by use of an infrared radiation heater or a carbon heater as means for melting and recrystallizing, it is possible to process the semiconductor thin film 2 having a large surface area at a time, whereby there is an advantage that productivity improves.

Additionally, as described, in the case of constituting the semiconductor device having a configuration in which an integrated circuit is formed and the semiconductor films 2 are superposed, the thickness of the semiconductor thin film 2 is preferably small as much as possible in a range where there is no influence in operations as an integrated circuit. Therefore, in the case of Fig. 11, for example, it is possible to make the thickness smaller by etching or grinding the semiconductor thin film 2, before forming the integrated circuit in Fig. 11(i) in the case of Fig. 11, and before forming the integrated circuit in Fig. 12(g) in the case of Fig. 12x.

Note that, in the above described respective examples, the case where a polycrystalline silicon thin film and a silicon oxide film are mainly used as the semiconductor thin film 2 and the release layer 4 respectively. However, materials for respective parts are not limited to them.  
[Effect of the Invention]

As described above, in the semiconductor device and the manufacturing method thereof according to the present invention, it is configured in a manner that after a semiconductor thin film is formed on a heat resistant substrate and a base body is formed on the semiconductor thin film, the heat resistant substrate is peeled off from the semiconductor thin film. Accordingly, there are effects that it is possible to prevent intrusion of impurities into the semiconductor thin film, to make a surface area larger, and

that productivity thereof is improved. Furthermore, the effects are that it is possible to realize an integrated structure in which a plurality of semiconductor thin film regions are formed on one base body and are electrically connected to each other. Furthermore, it is possible to realize a semiconductor device in which a degree of freedom in selecting a material for a base body is increased, and in which a lot of functions are integrated.

[Brief Description of the Drawings]

Fig. 1 is a schematic cross-sectional view for explaining a manufacturing method of a semiconductor device according to a first example of the present invention step by step in accordance with manufacturing steps thereof; Figs. 2 to 5 are schematic cross-sectional views for explaining manufacturing methods of semiconductor devices according to second to fifth examples of the present invention step by step in accordance with manufacturing steps thereof; Fig. 6 is a schematic cross-sectional view for explaining a sixth example of the present invention step by step in accordance with manufacturing steps thereof, the sixth example being a case where the manufacturing method of a semiconductor device according to the present invention is applied to a real semiconductor device; Figs. 7 to 12 are schematic cross-sectional views for explaining seventh to twelfth examples of the present invention step by step in accordance with manufacturing steps thereof, the seventh to twelfth examples being cases where the manufacturing method of a semiconductor device according to the present invention is applied to a real semiconductor device; Fig. 13 is a schematic cross-sectional view for explaining a conventional manufacturing method of a semiconductor device step by step in accordance with manufacturing steps thereof; and Figs. 14 to 16 are schematic cross-sectional views each showing a structure of a conventional semiconductor device.

In the drawings, reference numeral 1 denotes a heat resistant substrate; 2, a semiconductor thin film; 3, a base body; and 4, a release layer.

Note that the same reference numerals denote the same or equivalent parts.

Agent HAYASE Kenichi

Fig.1

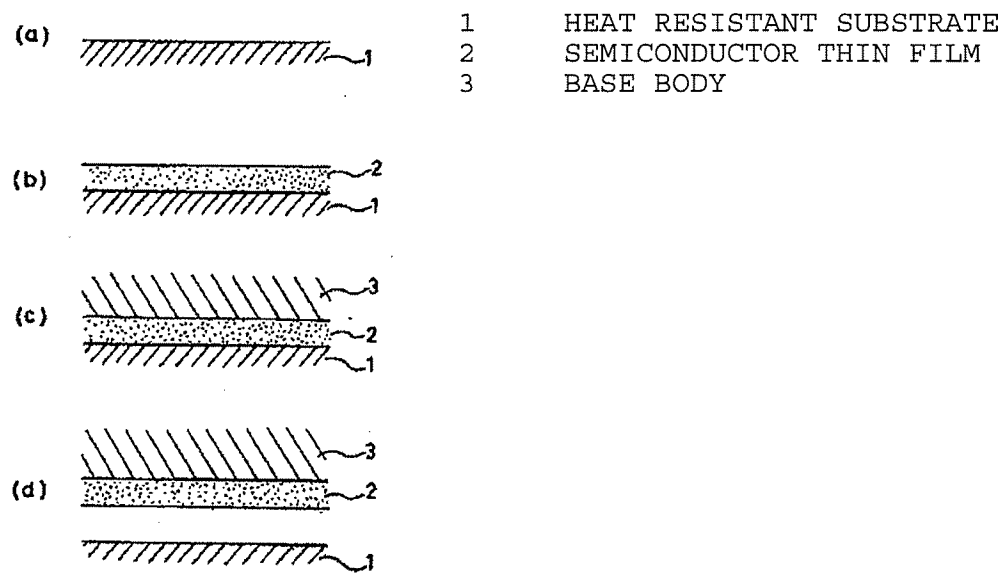


Fig.2

4 RELEASE LAYER

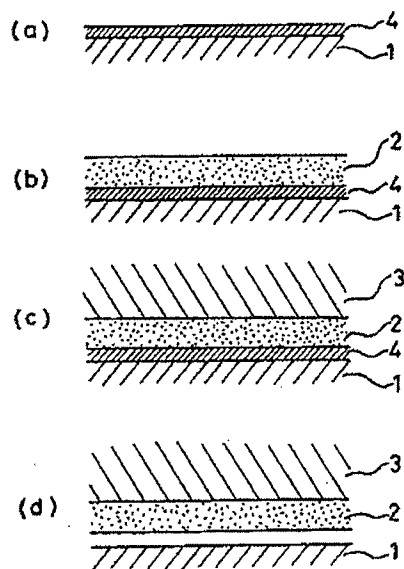


Fig.3

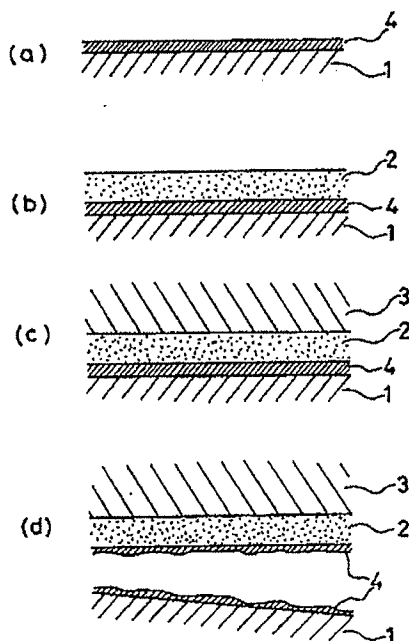


Fig.4

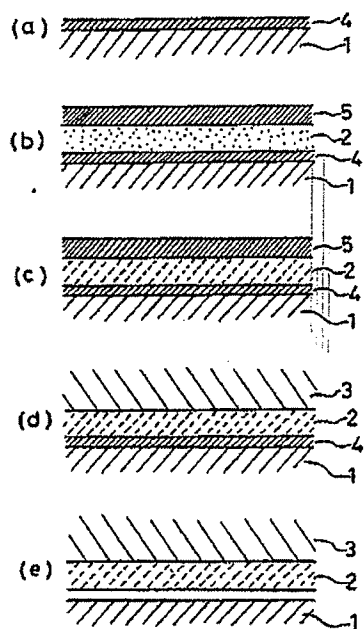


Fig.5

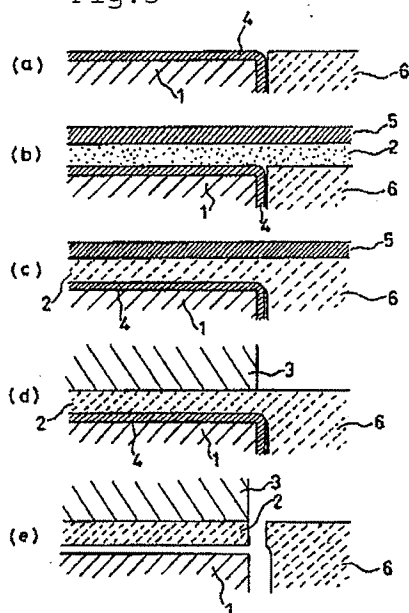


Fig.6

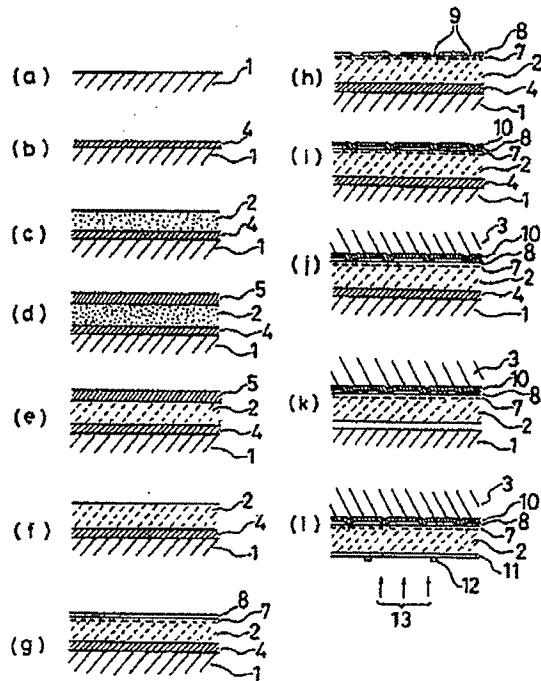


Fig.7

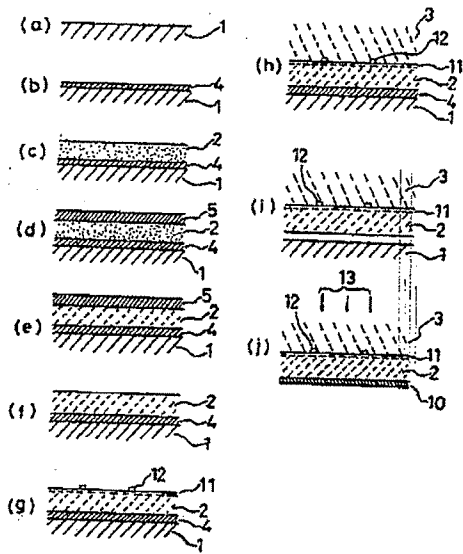


Fig.8

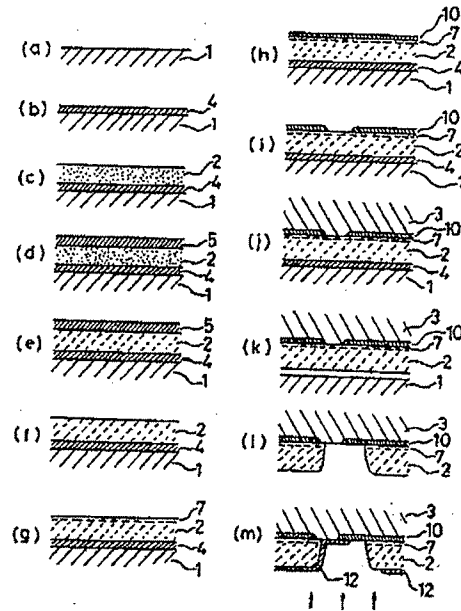


Fig.9

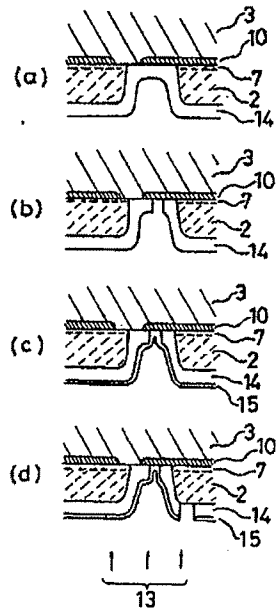


Fig.10

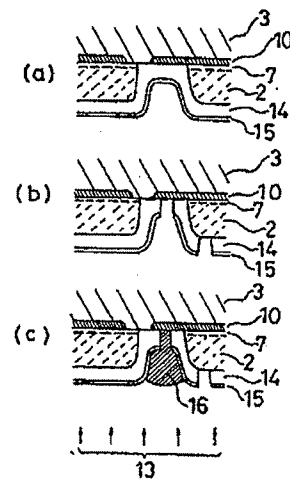


Fig.11

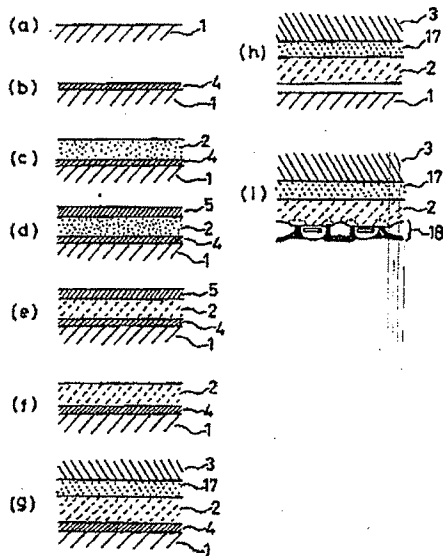


Fig.12

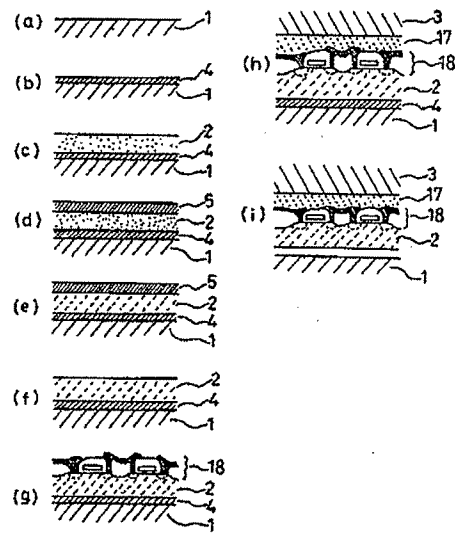




FIG. 1

- 1 HEAT RESISTANT SUBSTRATE
- 2 SEMICONDUCTOR THIN FILM
- 3 BASE BODY

FIG. 2

- 4 RELEASE LAYER